Student studies dry lines in Southeastern Wyoming

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In southeastern Wyoming, people are more than ready this time of year to get outside and enjoy the warmer weather. Then, suddenly, they feel the wind pick up and the temperatures cool -- signs of an impending thunderstorm.

Where these humidity or moisture boundaries—known as dry lines—meet, there is the potential for severe thunderstorms to originate. This is where University of Wyoming student Phil Bergmaier becomes curious about this phenomenon, which occurs in spring and early summer in the Cowboy State.

"I've always been interested in severe weather phenomena," says Bergmaier, a master's student in atmospheric science from Sadsburyville, Pa. "Dry lines are something that intrigues me. There's still a mystery about them. We don't fully understand them."

Dry lines are nonfrontal boundaries that separate two air masses—drier air at higher elevations in the west and humid area coming off the Gulf of Mexico from the east—with distinctly different humidity levels. A dry line drops moist air and dry air together. Such a convergent flow may lead to a rising motion of the air and may trigger a thunderstorm.

Bergmaier is lead writer of a paper, titled "A Dry line in Southeast Wyoming, Part II: Airborne In Situ and Raman Lidar Observations." The paper was officially accepted April 8 for publication in *Monthly Weather Review*.

The goal of this study was to describe the fine-scale vertical structure of a southeastern Wyoming dry line. This was done through analysis of airborne in situ data obtained during four separate flight tracks by the UW King Air research aircraft and remotely sensored water vapor measurements from a compact Raman lidar aboard the aircraft.

The Raman lidar was developed by Zhien Wang, a UW associate professor in the Department of Atmospheric Science. Lidar is a remote-sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.

The airborne Raman lidar measurements of a dry line are the first of its kind, and show the moisture gradient at the dry line in very fine detail, Bergmaier says.

"The lidar was able to essentially measure the water vapor in the atmosphere," Bergmaier says. "A dry line, by definition, is a moisture boundary separating very humid air in the east from dry air in the west. There is high water vapor to the east and it dries out as it goes to the east."

Following up

Bergmaier's paper was a follow-up to an initial study conducted by UW graduate student Patrick Campbell, under the supervision of Bart Geerts, a UW professor of atmospheric science. That study, published in 2013, was the first to document a dry line in southeastern Wyoming—one that occurred between Laramie and Cheyenne June 22, 2010, and dropped baseball-size hail in Laramie County.

In reference to the June 2010 dry line, Geerts says, "It acted in a way very similar to what we and others have observed in Oklahoma and Texas. Even though dry lines farther south occur over flatter, lower

terrain, this (Wyoming) dry line was very similar to those."

Geerts first began studying dry lines in 2002, but in the southern Great Plains, which includes Kansas, Oklahoma and Texas. Dry lines, which can range anywhere from 100 to 1,000 miles in length, also serve as adrenaline magnets for storm chasers in the Great Plains, as thunderstorms created from dry lines can sometimes spawn tornados, Geerts says. Rain from dry line-induced thunderstorms also can be beneficial to agriculture in the often parched Plains states, he adds.

Dry lines stay on the east side of the Rocky Mountains because the air is trapped or blocked by the higher terrain. The air mass to the east is more humid and the winds are calm, originating from the Gulf Coast. On the west side of the dry line, much drier air comes off of the Rocky Mountains, and it is windy.

"In Laramie, we're almost always on the dry side because we are at a high elevation," Geerts explains.

Bergmaier, who received his bachelor's degree in meteorology from Millersville University in Millersville, Pa., says the opportunity for him to write a research paper on the topic arose when Geerts decided to return to researching dry lines.

Geerts, Wang, Campbell and Bo Liu, an associate research scientist in atmospheric science, contributed to Bergmaier's paper.

Key findings of Bergmaier's study include:

— The June 22, 2010 dry llne exhibits characteristics similar to dry lines studied in the southern Great Plains. It is a convergent boundary with a sharp humidity gradient and buoyancy gradient, which means denser air is on the moist side of the dry line.

"Since dry lines haven't been looked at in this part of the country, are they similar to those that have been seen farther south?" Bergmaier asked. "They often are. I wouldn't necessarily say it's a complete surprise."
— The airborne Raman lidar yielded high-resolution images of specific humidity transects or a cross section, which shows changes in humidity across the dry line.

"We obtained a two-dimensional vertical view of the atmosphere—up and down and along the path of the aircraft," Bergmaier says.

— Convective available potential energy (CAPE), or a measure of atmospheric instability, was found to be higher within a few kilometers of the dry line. This means that the higher the amount of energy in the atmosphere, the more likely thunderstorms are to occur. Convective inhibition, or one measure of how much the atmosphere suppresses thunderstorm development, was low at these times, making the dry line environment conducive to deep convection.

"When I talk to people about dry lines, I generally say that the big thing is thunderstorms," Bergmaier says. "When we have a big tornado outbreak in the southern Plains, there is often a dry line nearby that can cause the storms. They often create prolonged storms that can cause destruction."

Bergmaier has corresponded about his study with officials at the National Weather Service in Cheyenne.

"They're interested in this for forecasting implications, being better able to anticipate storm development," he says. "Around here, that's the primary immediate benefit that I can see."

Bergmaier is working on his master's thesis, which is a climatological

study to determine how frequently southeastern Wyoming dry lines occur and at what level of intensity.

Provided by University of Wyoming